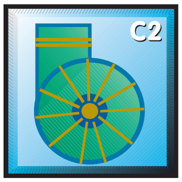

C2 Sewage Pump Stations

This chapter covers the design and construction of sewage pump stations and force mains. General requirements such as location, flows, reliability, and other special design details for pump stations are included.

C2-1 General Requirements

C2-1.1 Location, Site Selection, and Site Layout

C2-1.1.1 Location and Site Selection

Sewage pump stations are usually located at the low point of the service area. The pump discharges to the treatment works or to a high point in the sewer system for continued conveyance by gravity. Generally, sewage pump stations should only be used when gravity flow is not possible.

There is often little choice in siting sewage pump stations. Locations should be sited as far as practical from present or proposed built-up residential areas to reduce community impacts. The amount of land area required is a direct function of the station's size and type and of the need or desire for ancillary facilities such as a maintenance building. The station should be sited to accommodate reasonable pumping head, force main length, and depth of the gravity influent sewer(s). Other considerations are:

- Local land use and zoning regulations.
- Location on public right-of-ways versus private easements or site acquisition by the sewer purveyor.
- Permits (or variances) which might be required, such as grading, building, and so on.
- Availability of needed utilities, such as water, electricity, and natural gas.
- Applicable noise ordinances, especially when an emergency backup generator will be present.
- Space for future expansion, especially if population growth or development in the drainage area may increase substantially.

C2-1.1.2 Flood Protection

The station shall be designed to remain fully operational during the 100-year flood/wave action

C2-1.1.3 Access for Maintenance Vehicles

- Adequate access to the site is required for maintenance personnel and equipment and for visitors after construction. Adequate access during construction is required for construction equipment.
- Access road grade should not be excessively steep. The road and parking configuration should be adequate for vehicle turnaround or allow for one-way access.
- Adequate parking spaces for maintenance equipment and visitors should be provided.
- Additional easement or site acquisition may be required for the access road.
- Ingress/egress to the site near busy public right-of-ways may be affected by traffic.

C2-1.1.4 Fire Protection

- Contact the local fire jurisdiction for its requirements.
- Contact the local water purveyor to determine fire flow availability.
- Conform to the requirements of Standards for Fire Protection in Wastewater Treatment and Collection Facilities (NFPA) 820.

C2-1.1.5 Site Piping Layout

- Avoid installing buried pipes directly underneath each other, and minimize pipes crossing one another.
- Maintain appropriate minimum and/or maximum velocities in pipes.
- Provide appropriate restraint or thrust blocking for pressure pipe bends, etc.
- Conform to water purveyor's requirements for meter service, backflow prevention, etc.
- Provide potable water cross-connection protection in accordance with State DOH regulations.
- Provide flexible pipe connections to pipe penetrations through vaults and other underground structures.
- Consider a pig launch facility for the force main.

C2-1.1.6 Other Site Design Factors

- Landscaping may be required for aesthetic reasons or by local land-use agency codes. Use low-maintenance landscaping wherever possible.
- Provide exterior lighting, easily accessible for manual operation, in case maintenance at night is required.
- Provide appropriate security against vandalism.
- Consider intrusion telemetry alarms.

C2-1.2 Design Flow Rates, Hydraulics, and Number of Pump Units

C2-1.2.1 Design Flow Rates

The firm capacity of a pump station shall be equal to or greater than the peak hourly design flow. This peak design flow should be based on projected growth in the tributary area, future improvements anticipated in the collection system, and any phased improvements planned for the pump station and force main. It should also allow for a reasonable amount of wear to pump equipment, particularly in a tributary area that is at or near buildout. Because mechanical and electrical equipment is typically designed for a 20-year life, it is recommended that the peak design flow be based on a 20-year forecast or greater.

In addition to establishing the peak design flow, it is also necessary to review minimum flows and determine how the station will operate under low flow conditions.

C2-1.2.2 System Hydraulics

System hydraulics should provide an optimum balance for the project's force main characteristics, pump selection, and minimum and maximum flows. The force main should be small enough in diameter to minimize solids deposition yet large enough that the total head permits a good pump selection and minimizes the requirements for surge protection facilities. Recommended sizing considerations for force mains are covered under the force main section (see C2-3). A cost-benefit analysis is often useful in selecting the best alternative.

Pump stations shall be designed to operate under the full range of projected system hydraulic conditions. Both new and old pipe conditions should be evaluated, along with the various combinations of operating pumps and minimum and maximum flows, to determine the highest head and lowest head pumping conditions. The system should be designed to prevent a pump from operating for long periods of time beyond the pump manufacturer's recommended normal operating range.

Selection of head loss coefficients for pipes and valves should be conservative to allow for installation and equipment variations and normal aging of the pumping system.

C2-1.2.3 Number of Pumps

The number of pumps selected shall allow the station to provide the peak design flow with the largest pump out of order. Also, the number of pumps should correlate to the wetwell size and prevent excessively short periods between pump starts. On constant speed pump stations, the number of pumps is often based on the pumping capacity required to provide a minimum scour velocity in the force main.

C2-1.2.4 Pump Selection

Pumps should be designed for pumping sewage and capable of passing solids at least 3 inches in diameter. Pump suction and discharge should be 4 inches or greater. Exceptions to these criteria are discussed in the sections on grinder pumps and septic tank effluent pumps (see C1-10).

C2-1.2.5 Wetwells

Sewage pump station wetwells should be designed to provide acceptable pump intake conditions, adequate volume to prevent excessive pump cycling, and sufficient depth for pump control, while minimizing solids deposition.

For constant speed pumps, the minimum volume between pump on and off levels can be calculated using the following general formula:

$V = tQ/4$, where

V = minimum volume (gallons)

t = minimum time between pump starts

Q = pump capacity (gallons/minute)

Recommendations for various pump intake designs can be found in the references included at the end of this chapter. At normal operating levels, the designer should consider the following recommendations:

- Reduce or eliminate the free fall of sewage into the wetwell.
- Minimize prerotation of water at the pump intake.
- Provide adequate submergence to minimize surface vortices.
- Locate the pump intakes to minimize the forming of subsurface vortices from the walls or floor.

There are exceptions, however, to these criteria. For example, a prerotation chamber can be used to swirl the water in the same direction as the pump is turning in order to reduce flow through the pump at low wetwell levels. This provides turndown ability for the pump without requiring a variable speed drive. Another exception is drawing down the water level to flush out solids buildup in the wetwell.

Wetwells should be designed to minimize solids buildup. The wetwell should be either trench or hopper style with side slopes of 45 degrees or steeper (60 degrees is preferred). Maintenance procedures should be developed to remove any solids that do build up in the wetwell. A recycle pipe can be provided to temporarily route pumpage to the bottom of the wetwell to dislodge solids. Another method is to periodically operate the wetwell below its normal level, increasing velocities and allowing the pumps to pull in deposited solids.

In most cases, all electrical equipment in a raw sewage wetwell should meet the requirements of the NEC Area Classification as listed in NFPA 820.

Personnel entering the wetwell shall meet the requirements of current State Department of Labor and Industry confined space regulations, contained in Chapter 296-62M WAC.

C2-1.3 Grit, Grease, and Clogging Protection

If it is necessary to pump sewage prior to grit removal, the design of the wetwell should receive special attention. In particular, the discharge piping should be designed to prevent grit settling in discharge lines of pumps when not operating.

At some pump stations it may be beneficial to use bar screens, grinders, or comminutor devices. Design of bar screen facilities should include odor control and a method for handling the screening.

Grease in the flow entering sewage pump stations can present problems, both for the sewage collection pipelines (from the source to the station) and in handling or removal after flow is present in the wetwell. Grease floats on the surface of the liquid in the wetwell, and tends to cake on the walls and accumulate at the high pump start or upper level control setting. That can interfere with the pump control systems, including float switches, air bubbler controls, pressure bells (either static or encapsulated in a bulb or containment bag), and a variety of other mechanical or electrical control styles. (One control virtually free from grease-related problems is the ultrasonic level controller.)

Grease can also contribute to odor in the pump station. Allowed to build up to the point of collapse from the wall or other surface, chunks of grease can clog the pump suction, restrict flow through other features such as vortex breakers and flow-directing vanes, or just increase operation or maintenance problems in the station or the force main downstream from it. Provisions to limit grease from entering the system, such as regulating the allowable fats, oils and grease by sewer ordinances, pretreatment requirements, or other ways to put the burden for grease limits on the originator, should be considered. Adequate access to the wetwell for grease removal using mechanical means, such as vactor or septic pumping-truck suction pipes or hoses, blasting using high-pressure water to loosen the material, injecting grease control chemicals by pumping, drip, shock or maintenance dosing, or hand scraping and removal methods should be provided.

C2-1.4 Flow Measurement

Suitable devices for measuring sewage flow shall be provided at pump stations. Run timers should be provided on all pumps.

A wide variety of pump station level and flow control devices and instrumentation exists. Consider strategies that use instrumentation, monitoring, control, or process-driven concepts to integrate flow measurement into the overall perspective of the pump station design. With complete information at hand, or data available for computer analysis, great gains can be made in operating efficiency, maintenance prediction, budgeting, coordination of treatment processes, and other useful productivity steps.

C2-1.5 Surge Analysis

C2-1.5.1 General

Hydraulic surges and transients (water hammer) should be considered during design of pump stations and force mains. All systems should be at least conceptually reviewed for the possibility of damaging hydraulic transients. The transients can cause vapor cavities, pipe rupture or collapse, joint weakening or separation, deterioration of pipe lining, excessive vibration, noise, deformation, or displacement, and otherwise unacceptable pressures for the system.

Possible sources of damaging conditions include closing or opening a valve, pump starts and stops, sudden power loss, rapid changes in demand, closure of an air release valve, pipe rupture, and failure of surge protection facilities. Particular care should be taken in design if the expected change occurs in less than two wave periods, velocities are high (greater than 4 feet per second), the force main is long, the piping system has dead ends, or significant grade changes occur along the force main.

C2-1.5.2 Surge Modeling

If it is not possible in conceptual design or with simple manual calculations to ensure that the system is safe from excessive water hammer conditions, the system should be computer modeled. It is important that a computer modeling program is selected that suits the complexity of the project and has proven accuracy when compared to field-test results. The design methodology should include some method of checking the model results before construction. During facility startup, modeled results should be verified by gradually generating increasingly severe conditions. In this way it can be shown that the system will work as predicted prior to generating the worst-case design conditions.

C2-1.5.3 Surge Protection Facilities

There are many methods to provide surge protection, including the following:

- Open surge tanks.
- Pressurized surge tanks.
- One-way surge tanks.
- Appropriate check valve attachments.
- Pump control valves.
- Surge relief valves.
- Surge anticipator valves.
- Vacuum relief valves.
- Regulated air release valves.
- Optimizing the force main size and alignment.
- Electric soft start/stop and variable speed drives for pumps.
- Electric interlocks to prevent more than one pump from starting at the same time.
- Slow opening and closing valves.
- Increasing the polar moment of inertia of the rotating pump/motor assembly.
- Different pipe material to reduce surge forces.

Some of these techniques are not suitable for raw sewage. A combination of methods may be necessary to provide a safe operating system. Care must be taken in design so that adding a protection device does not precipitate a secondary water hammer equal to or worse than the original water hammer.

Reliability of the surge protection facilities is critical. Routine inspection and maintenance must be incorporated into the design. Where appropriate, redundancy should be provided for essential pieces of equipment, such as vacuum relief valves. Adequate alarms should be provided on surge tanks and similar equipment to give operators early warnings. Consideration should be given to preventing the pumping system from operating if the surge protection facilities are not operable.

C2-1.6 Odor and Noise Control

The design of both sewage pump stations and related pipelines should incorporate planning and construction techniques that consider odor and noise-producing conditions and solutions. Gravity and pressure mains carrying wastewater to and from the station present separate problems. The physical layout of the pump station should allow a variety of accessory systems to be applied that meet whatever odor concern is indicated, either before construction, in the planning/design phase, or after starting operation. Both the expected waste load, with associated chemical or unusual physical parameters, and the detention time and hydraulic characteristics of pipes and wetwell should be considered.

C2-1.6.1 Odor Control

Odor control is discussed in general terms in Chapter G2.

C2-1.6.2 Noise Control

Noise control for sewage pump station design depends on location, type, and layout of the station components, and local conditions, such as zoning, property use, or other ordinances (see C2-1.1.1). The regulations usually are set by local government, development covenants, or simply a cooperative understanding between the station owners and adjoining properties. The WISHA standards also speak to noise and safety considerations, specifically Chapter 296-62 WAC of the General Occupational Health Standards.

The most significant sources of noise are emergency generators, ventilation equipment, and, in some cases, motor or pump operations. Of these, the emergency generator is most significant. The generator may be powered by a piston internal-combustion engine, fueled by gasoline, diesel, propane, or natural gas, or powered by a rotary-power source, such as gas or steam turbine. These kinds of engines can produce mechanical, intake air, or exhaust stack noise, which may result in racking, pulsating, whining, humming, or other noises. A variety of sound insulation schemes are used to reduce the effects of these noises, and are rated by the degree of sound reduction they can achieve. Hospital-grade silencing is recommended as the design standard. Consider manufacturers' recommendations and careful study of the rated noise production values assigned to each component of a pump station in implementing a successful noise-reduction strategy.

C2-1.7 Operations and Maintenance

During the design of sewer pump stations, consideration must be given to operations and maintenance (O&M) needs. This is typically documented in an O&M manual (see G1-4.4) which conforms to the operating agency's O&M plan for the wastewater utility. The O&M manual should include provisions for:

- Detailed descriptions of all operating processes.
- Design data for pumps, motors, force main, standby power, overflow point and elevation, telemetry, and sulfide control system, as applicable.
- Pump curve with computed system curve showing design operating point.
- Startup and shutdown procedures.
- Analysis of critical safety issues.
- Inventory of critical components, including nameplate data for pumps and motors, etc.
- Description of the maintenance management system, including preventive and predictive maintenance.
- Vulnerability analysis.
- Contingency plan, including redundancy considerations.
- List of affected agencies and utilities, including after-hour contacts.
- List of local contractors for emergency repairs, including after-hours contacts.
- List of vendors and manufacturers of critical system components, including after-hour contacts.
- Staff training plan.

C2-1.8 Reliability

C2-1.8.1 Objective

Sewage pump stations should be designed to provide enough reliability that accidental spills of wastewater into the environment or backups of sewage into structures do not occur, except under the most extreme circumstances. All pump stations should be designed to EPA Class 1 reliability standards, unless otherwise approved by Ecology. Refer to G2-8 for additional information on reliability.

Reliability is achieved by:

- Specification of quality components.
- Good design.
- Redundancy of key equipment items.

C2-1.8.2 Equipment Redundancy

Components of the sewage pump station that should be designed with redundancy in equipment to provide capacity for peak design flows include:

- Pumps and motors.
- Motor control center components.
- Instrumentation and control for pumps and motors.
- Power supply.
- Emergency storage in lieu of permanent standby power.

Sewage pumps and motors should be selected to provide one redundant unit that matches the largest pump and motor unit in the pump station, and should handle peak design flows with one of the largest units out of service.

Each pump and motor unit should have a separate electrical supply, motor starter, motor sensor and alarm, electrical components, and instrumentation and control components. Each wetwell bay should have an instrumentation and control module for operation of the pumps and alarm conditions as designed.

Power supply to most sewage pump stations should include the primary electrical feed as well as standby power. Standby power can include permanent generators, portable generators, or secondary electrical feeds from an independent power grid.

Emergency storage should be included for all sewage pump stations that rely on portable engine generators for standby power, and should be considered for remote sewage pump stations where emergency response times may be long.

At locations where severe property damage could result from sewage backups caused by a pump station failure, it is recommended that the design include a manhole with a low elevation lid or an overflow pipe in the influent gravity sewage system.

C2-1.8.3 Emergency Power

All sewage pump stations should be designed with capability for emergency power in case the primary electrical feed is out of service. A portable engine generator unit that is plugged into a pigtail at the pump station commonly provides emergency power for small pump stations. Larger pump stations should have permanent engine generator units with automatic transfer switches to transfer the electrical feed from the primary to the standby unit when a power failure is detected by the instrumentation and control system.

Determining the engine generator's size should depend upon the requirements of starting and operating the pumps at peak possible load, and all ancillary equipment in the sewage pump station that could operate during a power outage.

A. Portable Engine Generators

Portable engine generators can be used at sewage pump stations where the total electrical demand is provided for in the wetwell; however, larger portable generators can be used if an adequate transport vehicle is routinely available during a power failure. Portable engine generators should be trailer-mounted and include adequate fuel storage. A suitable towing vehicle should be available at all times. A pump station that relies on portable engine generators needs a pigtail or proper electrical connection point for the generator.

Portable engine generators most commonly use gasoline engines, but are also available with diesel engines.

If portable engine generators are used, the wastewater utility needs to carefully evaluate its sewage pump stations to determine the number and size of portable engine generators needed during a major regional power failure, such as an ice storm or brownout.

B. Permanent Engine Generators

Permanent engine generators are recommended for larger pump stations and permanent facilities. Automatic transfer switches provide for quick transitions to standby power when the primary power fails. Permanent engine generators commonly use gasoline, diesel, or natural gas engines, depending on size.

Permanent engine generators should be located inside a building, or other weather-tight enclosure. Block heaters are recommended to ensure reliable startup in cold weather.

C. Fuel Storage

Fuel storage for both portable and permanent engine generators should be adequate to operate the pump station for a minimum of 12 and preferably 24 continuous hours without refueling. However, the decision on storage volume should also address access to a refueling vendor, accessibility of pump station during extreme weather, and fuel storage location.

Aboveground fuel storage is required to have liquid containment capability equal to the volume in the tank, and should be covered to prevent accumulation of precipitation. The fuel fill tube should be equipped to prevent overfilling of the tank.

Belowground fuel storage tanks and buried piping shall have double-wall containment and a leak detection system to prevent contamination of soils and ground water.

A fuel gauge can be incorporated into the instrumentation system for remote readings of the fuel supply status.

D. Secondary Power Grid

At some sewage pump stations, using a permanent engine generator may be undesirable because of noise impacts, exhaust emissions, concerns about fuel storage, or remote locations. In these cases, consider using a secondary power grid. A secondary power grid should only be considered if certain factors are present, as follows:

- Historical records from the power company demonstrating reliability of the secondary power grid exist.
- There is a completely separate power feeder line to the pump station from a substation or transformer that is independent from the primary feeder.
- There are independent regional transmission lines to the substation or transformer.
- A mutual understanding with the power company for priority maintenance and repair of the primary and secondary power feeds exists.

If adequate historical records are unavailable, Ecology recommends that a tertiary connection be provided for connection of a portable engine generator. Also, it is recommended that a Supervisory Control and Data Acquisition (SCADA) system be installed along with telemetry to alarm all power failures and record power failures at the pump station for both primary and secondary power feeds.

C2-1.8.4 Bypass Capability

Pump stations shall be designed to eliminate any bypass due to power outage, mechanical failure, or unusual flow regime. This is typically accomplished by some combination of the following:

- Flow storage.
- Standby electric generator.
- Portable electric generator.
- Power from two different electrical substations.
- Extra fitting on force main to allow quick connection for a portable pump.
- Design surcharge of gravity lines.

In extremely unusual circumstances Ecology may consider construction of a bypass to avoid excessive damage to adjacent properties. A manually operated valve that has a mechanical locking system shall control the bypass. The valve shall always be kept in the closed position. The keys to the lock shall be under the control of the responsible operator of the sewerage system.

C2-1.8.5 Overflow Storage Capability

The design of remote sewage pump stations using portable engine generators should include overflow storage. It is recommended that a minimum of 1 hour of storage be provided for peak flow conditions, and perhaps longer if the pump station is extremely remote. Ease of access during extreme weather conditions should be considered in the design of overflow storage capacity. The sewage flows should automatically go to the overflow storage when the wetwell reaches a predetermined elevation above the normal pump operating level. Storage outlets can be automatic or controlled with valves for manual discharge into the pump station. The design should include access covers to the storage tank so the storage can be hosed and cleaned to minimize odors after a backup event.

C2-1.8.6 Alarms and Telemetry

All sewage pump stations should be equipped with sensors for key operational conditions and the alarm signals should be connected to telemetry. The telemetry should send alarm signals to a location that is continuously monitored, such as a fire department, police department, answering service, security office, or continuously staffed treatment facility. See C2-2.1.1B for recommended alarm conditions.

The telemetry units generally include the following alternatives:

- Dedicated telephone lines.
- Dial-up telephone lines.
- Cellular telephones.
- Radio.

Any agency with more than five sewage pump stations should have a formalized standby and callout program to ensure that an emergency response can be provided when alarm signals occur during nonworking hours.

C2-2 Special Design Details

C2-2.1 General

This section describes special design details to be addressed for pump stations.

C2-2.1.1 Electrical Design

Electrical design for sewage pump stations shall conform to the National Electrical Code (NEC), National Electrical Safety Code (ANSI), and all federal, state, and local codes. Particular attention should be given during design to classifying the various enclosed spaces in the sewage pump station to ensure adequate ventilation, and using explosion-proof electrical equipment where necessary.

A. Instrumentation

Instrumentation at sewage pump stations should, at a minimum, include pump run times, pressure gauges, and voltage/ampere meters for the motors. In addition, flow meters and recorders should be considered for larger pump stations. Agencies with multiple sewage pump stations should consider installing a SCADA system to monitor and control sewage pump stations from a central location, reducing the staffing needed to visit each location each day.

B. Alarms

Alarms at sewage pump stations should include, in generally decreasing order of importance, the following:

- High water.
- Low water.
- Power failure.
- Pump failure.
- Surge control system failure.
- Engine generator failure.
- Fire alarm.
- Pump station intrusion.

C. Lighting

Sewage pump stations should include adequate lighting in all equipment areas to allow for repair and maintenance during non-daylight hours. Automatic lights should be carefully placed to avoid annoying neighbors.

C2-2.1.2 Water Supply

Water supply for sewage pump stations should be provided and include a reduced pressure backflow preventer with double-check valves, with an independent relief between the valves. Cross-connection control shall meet the requirements of DOH. Refer to G2-2.2.1 for information on potable water supply connection.

C2-2.1.3 Corrosion Control

The design of the wetwell should evaluate the potential for hydrogen sulfide in the wetwell from sewage. If low initial flows, long travel times, or high sewage temperatures could cause significant concentrations of hydrogen sulfide, it is recommended that the concrete and steel structure in the wetwell be protected from corrosion. Protection can be provided with a plastic liner or other means, such as high-rate ventilation at 30 air changes per hour with scrubbing of the exhaust through carbon canisters, or equivalent. Plastic liners can be formed into the concrete or adhered to the concrete walls after they have cured.

C2-2.1.4 Temperature and Ventilation

Design of the sewage pump station should also ensure that the temperature of the room that encloses the electrical and instrumentation equipment is within the equipment manufacturer's specifications. Generally, the electrical and instrumentation room's maximum temperature should be 104° F on the hottest summer day; design of ventilation equipment should be adequate to maintain a temperature at or below this maximum. The life of solid-state-based equipment, such as programmable logic controllers, variable frequency drives, telemetry equipment, and computers, will be increased if a lower maximum design temperature is used. Design of louvers for ventilating rooms that enclose engine generators should follow similar guidelines.

Design of all sewage pump stations shall conform to the Washington State Energy Code as defined in Chapter 51-11 WAC and codified in Chapter 19.27 WAC.

C2-2.1.5 Equipment Removal and Replacement

The sewage pump station design, including doors, vaults, and roof access panels, should include the capability to remove or replace all major equipment items, including the following:

- Pumps and motors.
- Electrical panels.
- Valves.
- Surge control components.
- Engine generators.

For sewage pump stations with larger pumps and motors, Ecology recommends that permanent monorails and hoists be included with a lift rating at least equal to the largest piece of equipment. For smaller sewage pump stations, portable gantry-style hoists or truck-mounted hoists may be sufficient.

C2-2.1.6 Accessibility

The sewage pump station site layout should provide for easy access by maintenance vehicles to key equipment for removal and replacement, including access to each piece of equipment listed in C2-2.1.5.

C2-2.1.7 Valves and Piping

It is necessary in all pump stations to provide a valve chamber for valves, piping, air and vacuum relief valves, and surge control components. Each pump discharge should include a check valve, an isolation valve, and pressure gauge.

Sewage pump stations that discharge into long force mains in which there is high likelihood of grease buildup or where the force main will have low velocities should be equipped with valves, piping, and end cap for launching of a pig to remove buildups of undesirable materials in the force main. Pig launchers typically include three valves so that a pig launcher can be isolated from the force main. After the pig is inserted into the line, the valves are adjusted to drive the pig through the force main using the force of the pumps. Additional water may be added to the wetwell to decrease the travel time in the force main.

If a pig launcher is included in a sewage pump station design, special care needs to be given to designing the force main terminus to include a pig catcher and the ability to remove materials driven out of the force main by the pig. See C2-3.11 for additional information about pig launching and retrieval.

C2-2.2 Wetwell/Drywell Pump Stations

Wetwell/drywell pump stations site the pumps below grade in a drywell immediately adjacent to the wetwell. Design should incorporate the latest standards from NFPA 820, the NEC, and L&I confined space regulations (Chapter 296-62 WAC, Part M). To provide an unclassified space, the facility should provide complete separation between the wetwell and drywell, meeting requirements in NFPA 820. Continuous positive pressure air ventilation from a source of clean air, with effective safeguards against failure, should be provided in the drywell, in accordance with the NEC and NFPA 820. No transfer of air should occur between classified and unclassified spaces. Air quality in the drywell space should be tested and recorded on a regular basis, in accordance with Chapter 296-62 WAC, Part M.

The drywell should be provided with at least one sump pump and a float switch alarm. Discharge should be into the wetwell or sewer pipe.

C2-2.3 Suction Lift Pump Stations

Suction lift pump stations incorporate self-priming pumps in order to locate the pumps above the water level and either eliminate or decrease the depth of the drywell. Priming tanks or vacuum priming systems are not recommended for raw, unscreened sewage on new installations. Maximum suction lift should not exceed the pump manufacturer's recommendations and should be based on a net positive suction calculation with a generous factor of safety. Typically suction lift should not exceed 15 feet.

An air release valve should be provided at the high point in the discharge piping and should vent into the wetwell above maximum water level.

Any structure housing the pumps or the motor control center should be physically separated from the wetwell and meet the requirements of NFPA 820 and NEC.

C2-2.4 Submersible Pump Stations

Submersible pump stations provide submersible pumps in the wetwell with the motor control center mounted above grade. Pumps should be readily removable and replaceable without dewatering the wetwell or requiring personnel to enter the wetwell. Check valves and isolation valves should be mounted outside the wetwell to facilitate access and contained in a structure suitable for protection against vandalism.

Control panels shall be physically separated from the wetwell, meet the requirements of the NEC, and be suitably protected from the weather, humidity, and vandalism. The pumps should be explosion-proof unless the control system can provide adequate assurance that pump motors in operation are submerged at all times. Electrical junction boxes should be easily accessible without entering the wetwell.

C2-2.5 Vertical Solids Handling Line Shaft Pumps

Vertical solids handling line shaft pumps (also referred to as vertical turbine solids handling pumps) hang into the wetwell with the motor and discharge connection above the wetwell in a dry room or outdoors. Generally, no drywell is needed. Like other types of pump stations, the design is subject to the requirements of NFPA 820 and the NEC.

C2-3 Force Mains

C2-3.1 Size

Except for small grinder and effluent pump installations, piping for force mains should not be less than 4 inches in diameter. As a general rule, whenever the velocity exceeds 8 fps, a larger pipe should be used.

C2-3.2 Velocity

At pumping capacity, a minimum self-scouring velocity of 2 fps should be maintained unless flushing facilities are provided. Velocity should not exceed 8 fps. Optimum velocities for reducing maintenance costs and preventing accumulation of solids range between 3.5 and 5 fps.

C2-3.3 Air Relief Valve

An air relief or air/vacuum valve should be placed at high points in the force main to relieve air locking. The surge effect on the system should be considered when sizing these valves.

Air relief and air/vacuum valves should be designed with cleanout or flushing attachments to facilitate maintenance. These valves should be protected from freezing and from damage by heavy equipment. Since they are subject to grease and scum accumulations, these valves should be inspected periodically to determine the need for flushing.

C2-3.4 Blow-Offs

A blow-off should be installed at low points of force mains where gritty material can accumulate and restrict flow. Blow-off valves also allow for removing raw wastewater before maintenance operations that involve opening the force main.

C2-3.5 Termination

The force main should enter the receiving manhole with its centerline horizontal and an inverted elevation that will ensure a smooth transition of flow to the gravity flow section. In no case, however, should the force main enter the gravity system at a point more than 1 foot above the flow line of the receiving manhole. The design should minimize turbulence at the point of discharge.

Consideration should be given to the use of inert materials or protective coatings for the receiving manhole to prevent deterioration from hydrogen sulfide or other chemicals. Such chemicals are especially likely to be present because of industrial discharges or long force mains.

C2-3.6 Construction Materials

Materials used for force mains include ductile iron, steel, polyethylene, polyvinyl chloride (PVC), fiberglass or reinforced plastics, and prestressed and reinforced concrete. The pipe material and interior lining should be selected to adapt to local conditions, including industrial waste and soil characteristics, exceptionally heavy external loading, internal erosion, corrosion, and similar problems. The system design and surge allowances may preclude the use of some materials.

Installation specifications should contain appropriate requirements based on the criteria, standards, and requirements established by the industry in its technical publications. Requirements should be set forth in the specifications for the pipe and methods of backfilling to preclude damage to the pipe or its joints, impede future cleaning operations, prevent excessive side pressures that may create ovulation of the pipe, or seriously impair flow capacity.

All pipes should be designed to prevent damage from superimposed loads. Proper allowance for loads imposed on the pipe should be calculated for the width and depth of the trench.

Use WSDOT specifications and refer to Chapter G2 for additional information.

C2-3.7 Pressure Tests

All force mains should be hydrostatically tested at a minimum pressure of at least 50 percent above the design working pressure. The method of testing should be in accordance with Section 7-11.3(11) of the Washington State Standard Specifications for Road, Bridge, and Municipal Construction, “Pipe Installation for Water Mains-Hydrostatic Pressure Test” or AWWA 906 test pressures. Leakage shall not exceed the amount given in the following formula:

$$L = \frac{ND\sqrt{P}}{7{,}400}$$

L = allowable leakage, gallons per hour

N = number of joints in length of pipeline tested

D = nominal diameter of the pipe in inches

P = average test pressure during the leakage test (psi)

C2-3.8 Connections

In order to avoid shearing force main pipes because of differential settlement, flex couplings should be used on force main pipes between the pump station structures, such as the pump station and the valve box. Flex couplings should also be used between the final pump station structure and the force main.

C2-3.9 Surge Control

Hydraulic surges and transients (water hammer) are dependent on a force main’s size, length, profile, and construction materials. Surge analysis, possible causes, and types of protection facilities for transient conditions are discussed in C2-1.5. Pipe pressure tests and thrust restraint should be based on maximum transient conditions, including an appropriate margin for safety.

C2-3.10 Thrust Restraint

Thrust forces in pressurized pipelines shall be restrained or anchored to prevent excessive movement and joint separation under all projected conditions. Common methods include thrust blocking and various types of restrained joints.

C2-3.11 Pig Launching/Retrieval Facilities

Provisions for launching and retrieving cleaning pigs should be considered in the design of a force main. See C2-2.1.7 for a discussion of when pig-launching capability is advised. Pig launching facilities may be as simple as a pipe wye or more elaborate, with a special launch chamber, bypass piping, and valves. In either case, provisions should be made for attaching gauges to monitor pressure.

Retrieval facilities may also be elaborate or simple. Elaborate retrieval devices are usually mirror images of the launch device; baskets, traps, or screens placed in the receiving manhole are among the simpler retrieval methods.

C2-4 References

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